riverrun, past Eve and Adam's: Molybdenums Wake

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Hard, Confusing, Entertaining is any attempt to understand James' joys, or the details of the commodius vicus molybdenum recirculation. Molybdenum (Mo) is a redox-sensitive element whose isotope fractionation in oceanic sediments is being established as a proxy for paleo-oceanographic conditions. In order to constrain the oceanic Mo cycle, it is necessary to understand its sources. The average Mo riverine influx to the oceans is not well established. Crystalline continental crust has a lighter isotopic composition than oceanic Mo by about 2 permil. We report here Mo isotopic compositions and concentrations from several closely-spaced river catchment profiles. We selected our sampling in such a way to monitor, for each sample suite, one or more of the following potential controlling factors: basement geology; fractionation during weathering; within-river precipitation (including lakes); anthropogenic contamination.

Our results show variable deviations of dissolved river Mo from average crystalline continental crust, between 0 and 1.9 permil. We observe a positive, but not simple, correlation between Mo concentration and isotopic composition, indicating that the riverine Mo system and thus global continental runoff are highly complex. Neither steady-state soil adsorption nor within-river precipitation cause a major isotopic fractionation. Weathering and laboratory leaching may lead to transient fractionation in some cases. The control by basement geology in most other cases is evident and can be documented in great detail along river transects and in tributaries; rock analyses supplement water analyses and confirm lithological control. Two very prominent effects are weathering of sedimentary (evaporitic) sulfates and oxidative weathering of sulfides. Several sub-economic molybdenite (MoS_2) occurrences in the Swiss Alps contribute isotopically variable Mo. Disseminated pyrite occurs in most magmatic, metamorphic and sedimentary rocks, with variable Mo concentrations. The weathering style (glacial vs. non-glacial) has an extremely high influence on dissolved Mo concentration in rivers. In our samples anthropogenic effects appear to be subordinate except in areas of intensive use of agricultural fertilizers.

Strong release of methane on Mars: Evidence of biology or geology?

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Methane on Mars

We have detected methane on Mars, and measured it simultaneously with water using powerful ground-based telescopes [1, 2]. Its presence in such a strongly oxidized atmosphere (CO_2, 95.3%) requires recent release; the ultimate origin of this methane is uncertain, but it could either be abiotic or biotic. On Earth, methane is produced primarily by biology, with a small fraction produced by abiotic means.

There is ample evidence that ancient Mars was wet and likely hosted habitable conditions (e.g. [3]). Moreover, the presence of extensive volcanism probably gave rise to widespread hydrothermal activity and the formation of rich aqueous subsurface reservoirs. Methane produced by living organisms or by geological processes (e.g., serpentinization) at that time could have been incorporated into hydrates. If such processes remain active on Mars below the permafrost, the byproduct gases (i.e. CH_4 and H_2S) may be trapped as hydrates at the base of a thickening cryosphere.

Tracing the Origin of Methane on Mars

In this paper, we present the spatial distributions of methane and water-vapor on Mars extracted from our complete spectral database now spanning seven years, and we compare these with other geological parameters. Both gases are depleted at vernal equinox but are enhanced in warm seasons (spring/summer), though often with dissimilar spatial distributions. In Northern Summer we observe a polar outburst of water but no methane, while in Southern Spring we observe release of abundant methane but little water.

Regions of methane release appear mainly over ancient terrain (Noachian/Hesperian, older than 3 billion years) known to have a rich hydration history. The combined methane source strength of three regions active in Northern Summer is comparable to that of the massive hydrocarbon seep at Coal Oil Point (Santa Barbara, California, USA).

[1] Mumma *et al.* (2009) *Science*, **323**, 1041. [2] Villanueva *et al.* (2009), submitted. [3] Carr (1999), *J. Geophys. Res.* **104**, 21897-21909.